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CPW-Fed CRR coconut tree shaped antenna for C/X band applications

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ABSTRACT

This paper presents a nominal, low-priced, new compact metamaterial Antenna with coplanar waveguide feed for C and X band applications. The proposed antenna has coconut tree shaped structure with length (L_{sub}) of 24 mm and width (w_{sub}) of 18 mm respectively. The tapered ground is and etched from the Teflon (PTFE) substrate with relative permittivity of 2.1 and thickness is about 1 mm. The negative index metamaterial consists of two CRR with modified ground is employed to design this antenna. In order to realize multi band characteristics, two closed ring resonator is engraved inside the coconut radiating patch, additional resonances are excited. In this, selection of the patch length and width are the major parameters taken into considerations when designing an antenna. The S parameter characteristics of the Antenna have been compared with the simulation results of the same. The 3D radiation pattern, reflection coefficient, stable gain and good Voltage Standing Wave Ratio is achieved splendidly.

Index Terms - coplanar waveguide feed; monopole antenna; CRR; Multi-band antenna.

1. INTRODUCTION

Multiband device is very essential component in communication systems. In past decades, many design methods for multiband have been proposed using metamaterial structure [1]. The extreme consequent of negative refractive index is nothing but the wave related with the antenna is bent to a sharper angle

that will commendably increases the radiated power of the antenna and can also double the range of frequencies [2]. Most of the metamaterial CRR antennas have been developed for the multiband applications. The most prominent method is used as closed ring resonator (CRR). The embedded resonators are the CRRs, which are required to concert the physical length and the impedance ratio to achieve the multiband, causing the complex design procedure.

As mentioned above, the design and development of an antenna working in one or more frequency bands [3], [4], is generally not an easy task. The popular antenna for such applications is microstrip antenna (MSA) where several designs of multiband MSAs have been reputed. Another essential candidate, which may complete favorably with microstrip, transmission with is coplanar waveguide (CPW) [5]. The CPW (Coplanar Waveguide)–fed planar antenna have the advantages of lower loss, less dispersion, easy integration with the radio frequency, simple configuration and is also more convenient for avoiding via holes. Moreover, the CPW has the applications of radar, missiles, aircraft, mobile communication base stations, satellite communications and handsets as well as in biomedical telemetry services. Therefore CPW-fed monopole is preferred in the antenna design. One of the main affairs with CPW-fed antennas is to provide an easy impedance matching to the CPW-fed line.

In this paper, a compact metamaterial coconut tree shaped antenna is proposed. Two triangle shape closed ring resonator and ground modification is utilized in this design which produce a larger wavelengths than the dimensions of the rings. This type of feeding system concludes the antenna bandwidth. This antenna was hired with Coplanar waveguide (CPW) feed technology. The antenna characteristics quietly improved by the coplanar waveguide which results in C and X band operation. The triangle shape CRR is introduced inside the patch resonator depending on the position of the coconut tree.

CRR metamaterials are peculiar that possess the capability to operate in many electromagnetic applications. With this presented length and width of the coconut tree shaped antenna designed for the multiband operation [6], [7]. The multi band frequencies are produced at the 5.15, 7.15, 8.5, and 10.5 GHz. This obtained band of operation covers the range of bands, C and X band. The antenna structure and design is discussed in section II, result in section III, and conclusion in section IV.

2. ANTENNA DESIGN

Fig. 1 shows that the configuration and parameters of the CPW-fed coconut tree shaped CRR antenna for multiband applications. The antenna is printed on dielectric Teflon (PTFE) substrate with a thickness of 1 mm, and relative permittivity of 2.1. The substrate dimensions are W_{sub} X L_{sub}, and the feed line has a width of 2 mm, which corresponds to a characteristic impedance of 50 ohm, and Gap between the ground and patch is about 0.3 mm. The feed line is tapered to optimize the impedance matching to the antenna's coconut patch. The antenna's rectangular ground plane is etched on the same side as the patch. The process of ground modification consists of curving the rectangular ground plane at the top and cutting out rectangular shaped slots from its sides.

This modification to the ground plane enhances the matching characteristics between the patch and the feed line, which results in the antenna exhibiting C and X band performance. To achieve the C and X band, the CRR is added to the antenna's coconut patch resonator. As such unusual material which is also called left handed material is created by the use of triangle shape closed ring resonator. A pair of concentric triangle metallic rings is placed inside the coconut tree shaped patch radiator. The gap between the CRR preserves large capacitance.

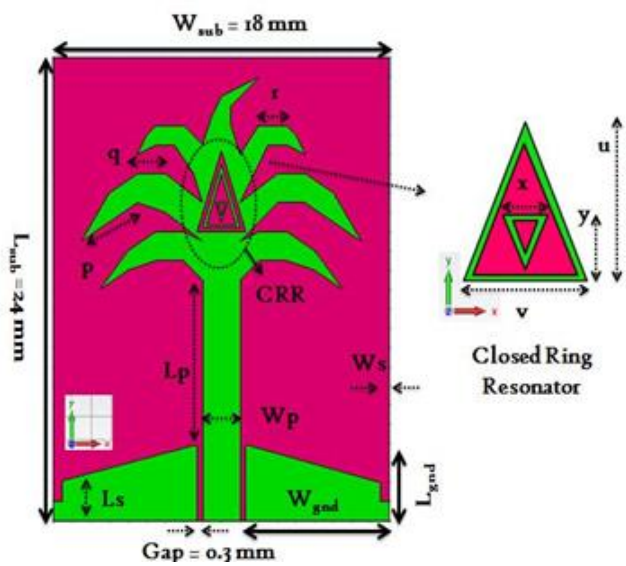

Figure 1 The geometry of the CRR coconut tree shaped antenna

The optimal parameters dimensions of the metamaterial antenna are shown in table 1. Fig 2 shows the iterations of the CRR coconut antenna. Thus iterations of the coconut tree shape patch antenna are as follows:

Ant 1) Create a tapered CPW feed line for the coconut tree shaped patch resonator.

Ant 2) Embed a two triangle CRR inside the coconut tree shaped patch.

Ant 3) Modification in ground is used to extend the impedance bandwidth for multiband performance.

Table 1 optimized parameters dimensions of the proposed antenna

Parameters	mm	Parameters	mm
Wsub	18	Lsub	24

Wgnd	7.7	Lgnd	4
Gap	0.3	Z(thickness)	1
Ws	0.5	Ls	2
Wp	2	Lp	8.5
p	2	q	1.5
r	1.5	ε	2.1
u	4.5	v	2.6
x	1.8	y	1.3

3. RESONANCE AND RADIATION CHARACTERISTICS

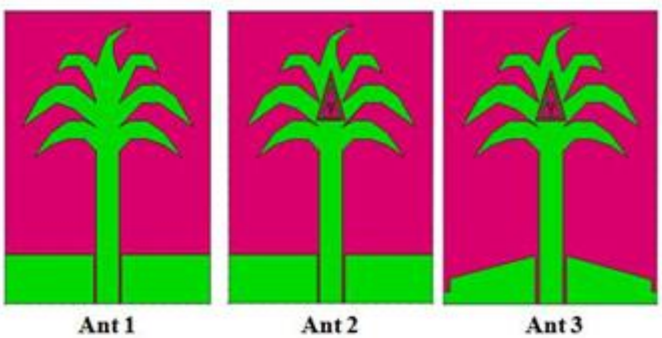

Figure 2 The iterations of the CRR coconut tree shaped antenna

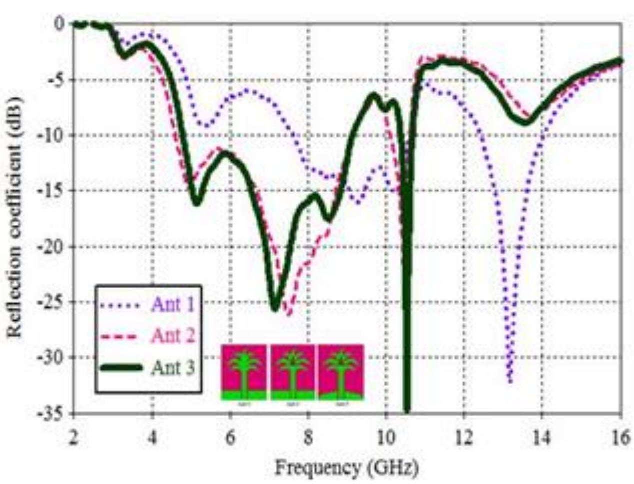

Figure 3 Proposed CPW-fed metamaterial antenna reflection co-efficient vs. Frequency

The proposed CRR CPW–fed coconut tree shaped antenna for multiband applications is designed. As can seen from the simulated results, the antenna excited at 7.15 GHz covers C band and 10.5 GHz covers X band with a -10dB impedance, respectively. Fig 3 shows the reflection coefficient versus frequency for antenna 1, 2 and 3.

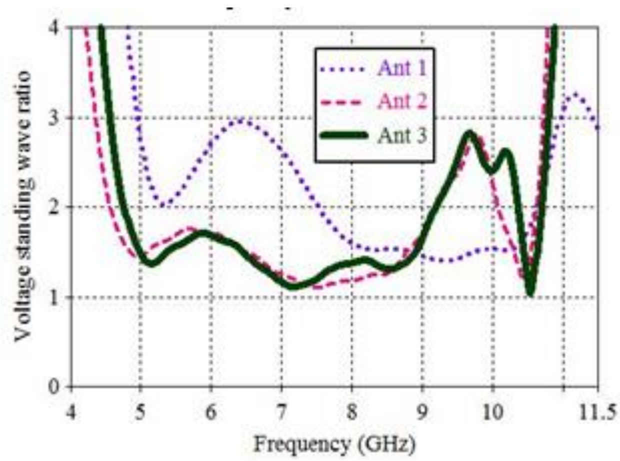

Figure 4 Proposed CPW-fed metamaterial Antenna VSWR vs. Frequency

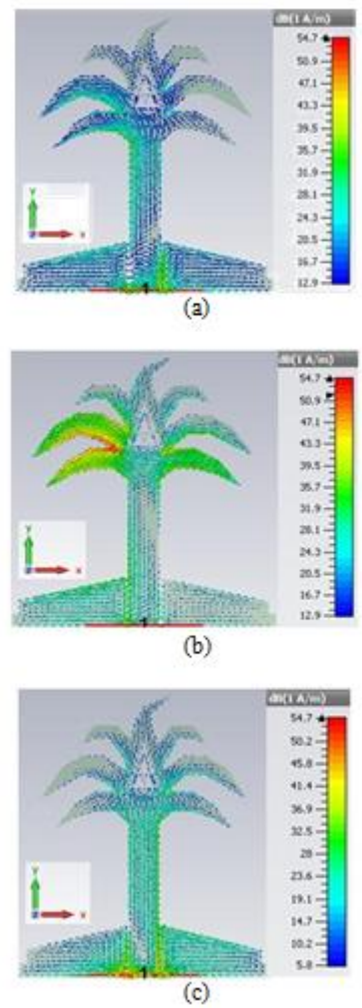

Figure 5 Simulated current distributions at frequencies of 4, 7 and 10.5 GHz for proposed antenna

The VSWR of antenna is marginally affected by varying the dimensions of the CRR configuration. Thus the simulated coconut tree shaped antenna has VSWR ≤ 2. Fig. 4 shows the comparison of simulated voltage standing wave ratio for the

proposed CRR coconut antenna 1, 2 and 3. Figure 5 (a) shows the surface current distribution near the resonance frequency at 4 GHz. As shown in the figure, the electric current is mainly distributed between the ground plane and patch. Figure 5 (b) shows the surface current distribution near the resonance frequency at 7 GHz. It is mostly distributed on the ground plane and the coconut patch radiator to achieve multiband, two CRR are placed inside the patch radiator. Figure 5 (c) shows the surface current distribution near the resonance frequency at 10.5 GHz. It is observed that the current is concentrated more on the CPW line, the edge of the patch antenna and feeding stubs, where both x- and y-components of the currents exist. Therefore we can achieve good multiband with fine tuning of ground.

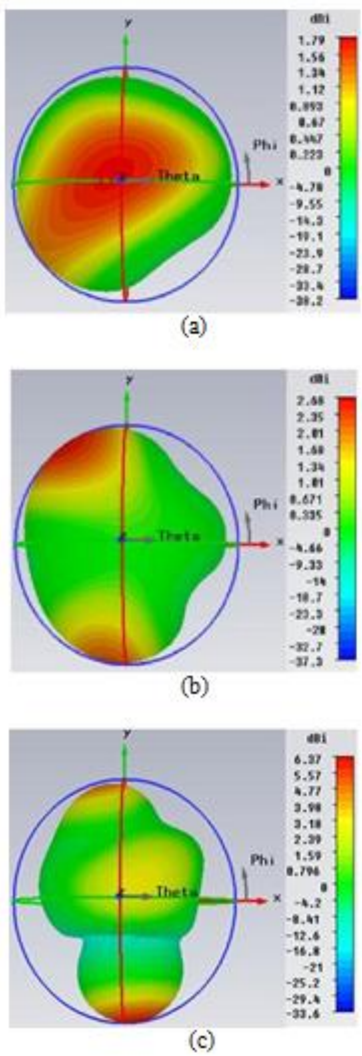

Figure 6 Simulated 3D radiation pattern of the proposed antenna at frequencies of 4, 7 and 10.5 GHz.

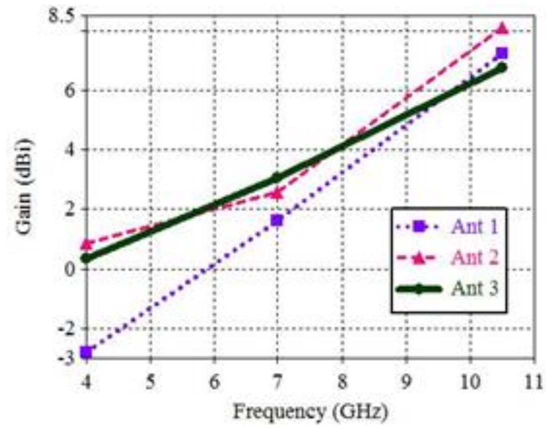

Figure 7 Gain of the proposed antenna

The 3D pattern of the coconut antenna is shown in the fig 6. Within the operating C and X bands the simulated antenna gain for the CRR coconut antenna is 0.3 to 6.7 dBi. Simulated realized gain for the proposed antenna is shown in the fig 7. The reflection coefficient, VSWR, 3D radiation pattern of the coconut antenna are analyzed the result is good agreement with the above mentioned parameter.

4. CONCLUSION

CRR Coconut Tree Shaped Antenna with CPW Feed for multiband applications is analyzed. The proposed CPW CRR antenna has simple geometry and design process. The coconut antenna has dimensions of 24 mm × 18 mm with thickness of 1 mm on a Teflon substrate with dielectric constant of 2.1 and height 1 mm. Good reflection coefficient characteristic with moderate gain is also marked. The simple new structure, compact dimensions, makes it an absolute candidate for the C and X band applications.

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